EUV and X-Ray Metrology Opportunities for NIST

Potential NSLS-II Partnerships for Detector-Based X-Ray Radiometry

Rob Vest, NIST

NIST Proposal for Radiometry

- Expand our existing calibration capability into the x-ray region with sub-percent (2-σ) uncertainty to realize the U.S. national scale of detector responsivity.

Current energy coverage:
5 eV to 250 eV

SURF III is a 380 MeV synchrotron, so the maximum photon energy is around 300 eV.

Proposed energy coverage: 5 eV to 20,000 eV

Calibration Chain

Absolute Detector: cryogenic radiometer,
free air ionization chamber, etc.

Time-consuming, difficult transfer

Working standard (*e.g.*, Si photodiode)
kept by NIST

Relatively easy transfer

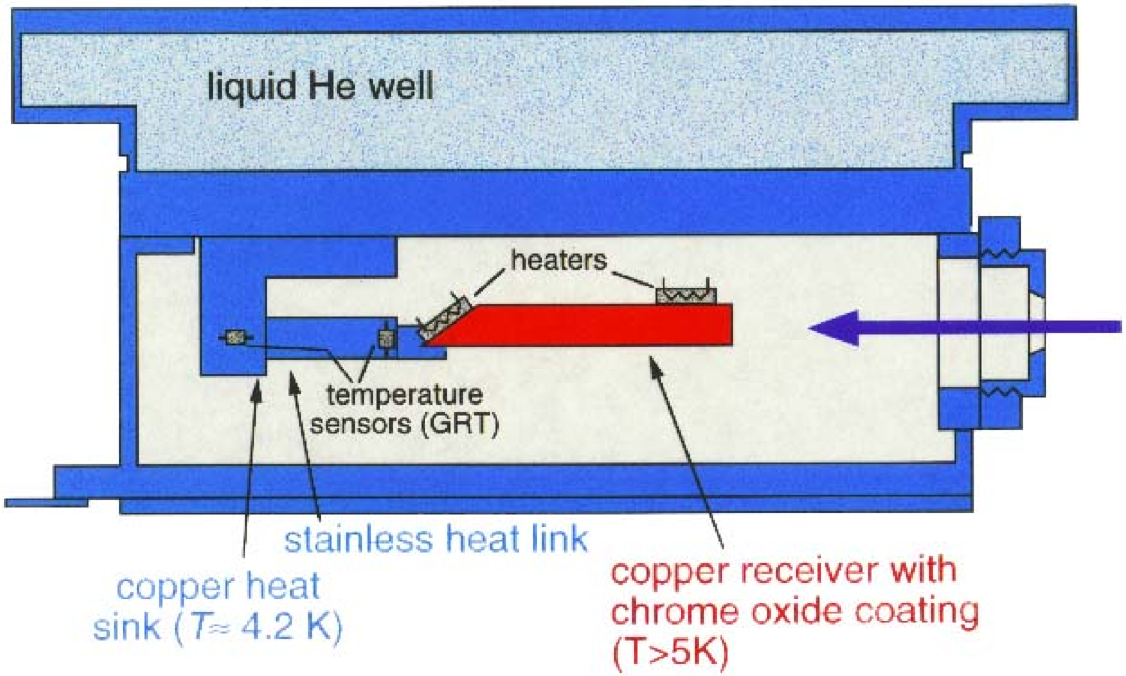
Transfer standard (*e.g.*, Si photodiode)
issued to customer

So Can This Work?

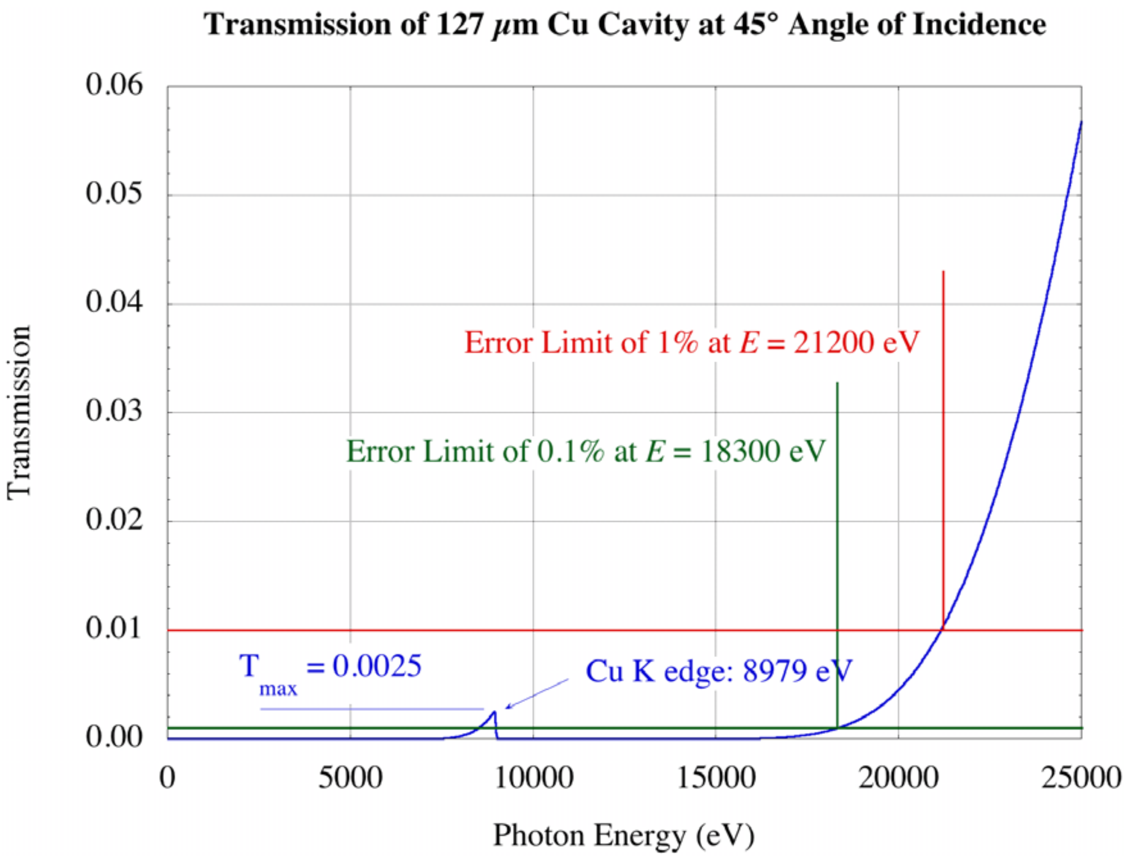
- ? Absolute detector useable up to 20 keV
- ? Standard detector useable up to 20 keV
- ? Source useable up to 20 keV

Cryogenic Radiometer

- Calibration traceable to electrical standards



Cryogenic Radiometer



Calculated with effective thickness of 180 µm. To reduce T_{max} to 0.001, need an effective thickness of 210 µm, or 148 µm at 45°.

- Transmission is <0.1% for energies below 18.3 keV
  - Except region around Cu K edge at 9.0 keV
- Transmission is <1% for energies below 21.2 keV

Calculations from CXRO website: http://www-cxro.lbl.gov/optical_constants/

Si Photodiode

- Needs to be calibrated against cryogenic radiometer or other absolute detector.

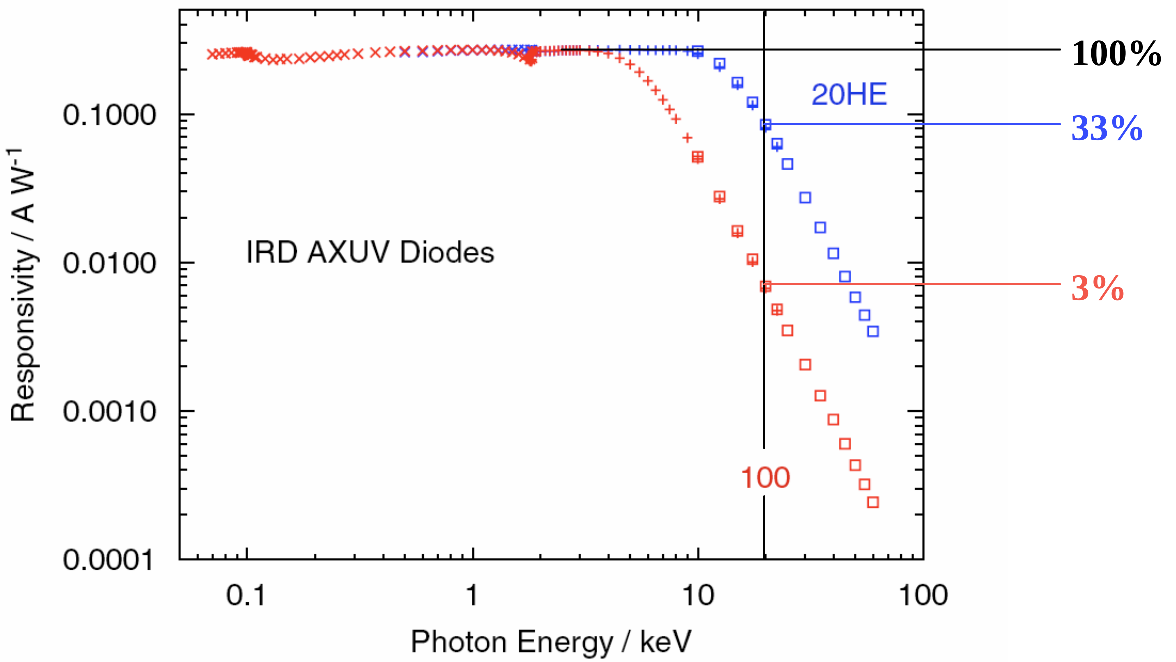


Figure from: M. Krumrey *et al.*, NIM A, 568, 364-368 (2006).

Possible NSLS-II Sources

Couldn't scan or download the image last night, so no plot, but it's in your Summary handout on p. 5.

25-m Bend Magnet

- Critical energy: 2.4 keV
- Photon flux >3×10^{12} / s / 0.1% to 8.5 keV

3-Pole Wiggler

- Critical energy: 6.0 keV
- Photon flux >3×10^{12} / s / 0.1% to 20 keV

Yesterday's beamline development talk (J. Hill) envisioned a radiometry beamline on a 3-pole wiggler source.

So This Could Work

- ✓ Cryogenic radiometer useable up to 20 keV
- ✓ Standard detector useable up to 20 keV
- ✓ Source useable up to 20 keV

Radiometry Requirements

- Optical Power:
  - 1 µW current radiometer.
  - 10 nW with proposed low-noise radiometer.
- Energy Resolution: Currently 250 meV at 100 eV.
- Beam Size: A 4 mm by 4 mm spot is OK, but 1 mm^2 or slightly smaller is better.
  - Small (1 mm^2) detectors
  - Spatial uniformity (homogeneity) mapping
- Coherence: No requirements.

More Radiometry Requirements

- Polarization: Linearly polarized source allows separation of s- and p-responsivities, but near normal incidence, this is not an issue. Circular polarization may eliminate the need for two calibrations for unpolarized source applications.
- Beam Stability: Unexpected step changes on the order of 1% is a problem. Slow (linear) beam current changes are easy to handle.
- Spectral Purity: Greater than 99% of power should be in-band.

NIST Role in JPSI?

- *If* JSPI develops an active detector program;
  and
- *If* a more collaborative or targeted scale dissemination method is desired;

- *Then* participation in JPSI may offer an alternative method of disseminating the NIST detector responsivity scale to NSLS users.

JPSI = Joint Photon Science Institute
NSLS = National Synchrotron Light Source

Final Comment

Because:

- Radiometry is not as “sexy” as nanotechnology
- Generally does not require the high brightness or fine energy resolution that is the *raison d’etre* for NSLS-II
- In the Beamline Advisory Team (BAT) and General User / Partner User (GU/PU) access model, we may need to convince NSLS to design and build a beamline.

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Be noisy or be forgotten!